INTESTINAL OBSTRUCTION: AN OUTLINE FOR TREATMENT BASED UPON THE CAUSE OF DEATH.

A STUDY OF FOUR HUNDRED EXPERIMENTALLY PRODUCED LESIONS.[1]

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PHYSIOLOGISTS often quote the sentiments of Montaigne: "With how little anxiety do we lose the consciousness of light and of ourselves." By this they would convey the idea that the act of dying is as painless as the act of falling asleep, and also as little perceived. Nevertheless, so strongly rooted in the human mind is the desire to live, that the profession of medicine has for its chief purpose the lengthening of human life. Hence, it is natural that the study of the causes which bring death to a cell, to an individual, or to a race of men has for long been a favorite and engrossing one. None of us without giving thought can realize how many and how different are the actual and underlying causes which terminate life. "The supreme fact," says Adami, "that sooner or later death comes to all men has profoundly affected all human thought, and the various religions of the world may be regarded as the evidence of man's determination to rise superior to the dissolution of his body." In the unicellular organism there is no destruction of the essential living matter but a multiplication thereof: each spore carries on the life. There is no death in the ordinary interpretation of the word. "It is with the appearance of the multicellular organisms that natural death enters into the world." In the cellular differentiation it comes about that the germ cells are given the inherent power of perpetual life, while the somatic cells, through the elaboration of which the individual organism reaches its final development—side-tracked groups, as it were—are destined to hold and live together for a span and then to undergo dissolution.

There are in general two forms of death which may befall the somatic cell—the physiological and the pathological. The pathological form of death may be induced by mechanical, physical, chemical, or bacterial agents. With these in this paper, which deals with the cause of death in duodenojejunal obstruction alone, I hope to demonstrate that we are not concerned. Physiological death, on the other hand, that form of dissolution of somatic entity which has been studied so thoroughly, so exhaustively, in the pioneer work from the Johns Hopkins laboratories, the death following parathyroidectomy and that associated with adrenal and pituitary destruction or removal, this physiological form of death is that which immediately concerns us. I understand physiological death to comprise not only the dissolution which follows the removal of certain substances by destruction of their secreting cells, such as the parathyroid, but also that dissolution of somatic life which is brought about by the mechanical interference with detoxication of the normal secretions of the body. Putting it concretely, I may say that a barrier which may prevent the normal distribution of enterokinase, or the normal reaction of anti-enzyme upon enzyme, is the cause of death which is physiological and somewhat of the same type as is the death brought about by removal of glandular secretions, so-called internal in character. It is not to be denied, of course, that these thoughts suggest ascribing to the duodenum a function, I believe, hitherto and as yet unknown, that of internal secretion.

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In whatever manner this may be rightly considered, I ask you to allow me to start with the hypothesis that the intestinal barrier which closes the lumen works no ill to the organism save through an interference with the physiological exchange or balance of the duodenojejunal secretions, and that the resulting death is physiological in type. I ask you to assume for the moment—and for this we have adequate proof—that in intestinal obstructions there is no appreciable damage to the individual through the nervous system from the direct trauma of the obstruction; that there is no lethal infection of bacterial origin; that the element of decomposition of food does not enter into the picture at all—in short, that all pathological forms of death are eliminated. I shall strive to detail to you the simple, and withal possibly inefficient, measures which I have taken in my efforts to prove these things to myself.

NERVOUS EFFECT OF INTESTINAL TRAUMA. Clinically surgeons have recognized a difference of degree in the shock produced by cutting the intestine in various places: the nearer one approaches the pylorus, other factors being equal, the greater the shock. Indeed, in the execution of the well-known pyloroplastic operation devised by Finney, it has been, I believe, commonly recognized that a shock to the patient might occasionally be clinically noticeable at the moment of actual section of the pylorus. Operations which will be described later and in the course of which this highly sensitive mechanism was entirely removed or seriously injured, and furthermore operations in the remotely aboral portions of the small intestine which technically were associated with precisely the same amount of traumatism as those in the duodenum and jejunum, afford, under study, point blank evidence that the nervous shock or reaction (let it be called what it may) has nothing whatsoever to do with the cause of death in the form of intestinal obstruction under consideration. Indeed, I have been led to the conviction that the infliction of even unusual mechanical traumas incident to various operative procedures upon the alimentary canal, not excepting the thoracic œsophagus, is incapable of producing more than a transient and unimportant nervous reaction. It stands to reason that if a dog would live for weeks with iliac obstruction and dies at the end of a few hours with duodenal obstruction, and that if the same dog can be made to live also for weeks, if but the slightest drainage be instituted, something far more important than mere mechanical injury is the cause of death. Obviously the traumatism in each case is equal. Incidentally, it may be noted that whatever nervous traumatism might be associated with the dilatation of the proximal loop, would presumably be greater where the greater dilatation occurred. In the majority of fatal cases of duodenal obstruction, there was little or no dilatation; it rarely has time to develop, whereas in the chronic aboral obstructions it is frequently found.

INFECTION OF BACTERIAL ORIGIN. No one could pretend to read the literature of intestinal obstruction and not be acquainted with the contributions which have been made from the Johns Hopkins Laboratory on the subject of bacterial emigration oral to the obstruction. These studies have contributed widely to our knowledge of the pathological type of death which unquestionably occurs from obstructions in the aboral portions of the ileum and from occlusions of the great gut. It is, however, the physiological form of death alone with which I am concerned; with the fulminating prairie-fire-like toxemias which, unheralded and often in a few hours, destroy the victims of duodenal obstruction. In dogs the clinical syndrome is usually typical; the muscular tremors localized in certain groups of muscles, the tachycardia, the rapidly advancing coma and death, followed by a characteristic stiffness. Clinically this picture is not far different from that observed after parathyroidectomy.

The pathological form of death which results from obstruction at or near the ileo-cecal valve and which may well be of bacterial or stercoraceous origin, has not been the special object of our study, and of it, therefore, I am not qualified to speak. I would note, however, in passing that it is slow and tortoise-like in overtaking the somites, suggesting in every detail a process quite different from that which has been the special subject of my studies. Furthermore, it should be noted that while the duodenum possesses a rich flora, it is exceedingly poor, at least in the healthy dog, in pathogenic forms, and continental observers, as well as your own, have found blood cultures taken from cases of duodenal obstruction entirely sterile.

With these premises then I ask you, for the academic purposes of argument, to assume that in obstruction of the intestine two entirely separate and distinct forms of death are to be differentiated: the one duodenal and purely physiological, due to an unknown disturbance of the duodenal secretion or balance, the other ileo-colic and purely pathological; the one a true auto-intoxication, the other a true exo-intoxication.

DUODENAL AUTO-INTOXICATION. The following impressions have resulted from the study of over 400 cases of duodenal or oro-jejunal obstruction produced experimentally during the past five years at the Surgical Research Laboratory of Columbia University. Although the series is not small, the positive conclusions which are offered by it are regretfully small. This may be attributed in part to the natural deficiencies of the experimenter and to the great intrinsic difficulty of the task, and also very fairly in part to the fact that the work has been done at odd moments taken from an annoyingly engrossing practice and amid surroundings sadly incomplete and unfit. I mention this because I seek your indulgence.

A chronicle of the steps which have led to the above outlined position on intestinal obstruction is as follows: About five years ago, while modifying the McGraw elastic ligature so as to substitute common every-day twine for the perishable elastic, and also with a view to remove sizable apposed portions of gut and stomach wall, Dr. Weir at the time considering this a necessary part of the technique, we were suddenly confronted by the perplexing coincidence that all our animals died. There was no peritonitis; there was no gross lesion discoverable within or without the abdomen. We noted an early rigor mortis, and that before death the heart beat was accelerated, the gait was peculiar, owing to spasticity of the hind legs, and there were well-defined muscular twitchings. The technique had embraced the closure of the duodenum (Fig. 1). At that time no information was forthcoming as to the cause of these phenomena and I could find nothing regarding it in the literature. It was not long, however, before Roger, in France, began an allied series of experiments which to some extent corroborated our own findings. All these experiments, as well as the most recent ones, have been based on the utilization of this potential gastro-enterostomy by the twine triangular ligature as a control. It seems reasonable, and indeed is easily susceptible of proof, that the twine will cut out and give drainage in healthy stomachs of normal dogs at about a constant time, seventy-two hours. It is a coincidence of import that the physiological death which we have been studying usually takes place in about the same time as is necessary for stoma drainage to begin. Thus we have come to regard the cutting out of the stoma as a sort of index of resistance of the individual to the intoxication process, and we have proceeded to create different degrees of toxicity, which we found we could do by varying the position of the obstruction and of chronicling the results in terms of gastric drainage. For it should be noted that almost any form of drainage, whether through the normal channel of the gut, or abnormally through the stomach or even through an entero-anastomosis of the aboral loop with the oral loop, will counteract the lethal effects of what we believe to be a physiological death, due to a disturbance of physiological intra-enteric enzymotic balance.

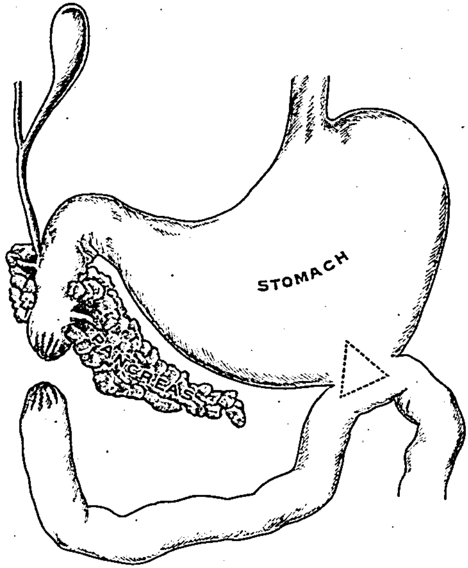

Fig. 1.—Duodenal obstruction; twine triangular control. In this class of experiments the bile and pancreatic fluid do not drain. Death before stomach drainage almost invariably occurs irrespective of the presence or absence of food in the stomach. This short-loop type should be given retrograde lavage or anti-enzyme serum from the long-loop class.

Determination of Aboral Lethal Line for Physiological Death. Logically the first step after determining by a long series of experiments that death followed the closure of the duodenum before drainage became established through the triangular stoma, was to ascertain the effect of practising a similar technique, but modified by placing the obstruction in the jejunum (Fig. 2). Another lengthy series of experiments determined, I believe with reasonable accuracy, that death would not occur in a medium-sized dog until after the free drainage of the stomach, that is, several weeks, in any case when the obstruction lay more than 35 cm. aboral to the pylorus. This distance probably varies somewhat according to the size of the dog. The individuals exposed to this type of experiments will in future be referred to as the "long-loop dogs." For to them on account of the possible production of anti-enzymes, or protective bodies of unknown character, there attaches a particular and perhaps a lasting interest. These long-loop dogs, barring ordinary accidents, survive the moderate toxemia to which the obstruction gives rise and will live often for several months without apparent discomfort or loss of body function. On autopsy, the oral segment was found to be but moderately dilated, as a rule, and the evenness

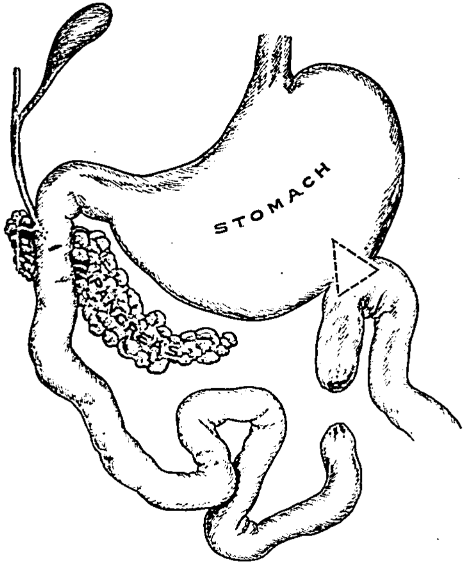

FIG. 2.—Jejunal obstruction. The length of the oral loop was more than 35 cm. In this class of experiments the dog lives until the twine cuts the stoma and often for months thereafter. Obstruction between this (35 cm.) and the greater pancreatic duct is almost always fatal before gastric drainage begins. Does the intestine detoxicate by the addition of an anti-enzyme, or does it save life by offering a larger field for absorption, thus diluting the toxic elements? This long-loop class may furnish a protective anti-enzyme serum for use in the short-loop class.

of digestive function suggested the phenomenon of gastro-proteid digestion. But the theoretical considerations which offer themselves as a result of this particular group of experiments must not interfere with this chronicle of plain observed facts.

DETERMINATION OF ORAL LETHAL LINE FOR PHYSIOLOGICAL DEATH. The next step naturally was to determine the oral limits of the point of obstruction beyond which one might go and not encounter physiological death within the time limit of triangular control. Because of the studies of Roger upon the gastrotoxins, and of the recent publication of Bolton describing a gastrotoxic serum, it is of very great importance to know whether the lethal bodies take their origin from the gastric mucosa, from the pancreatic fluid, or from the duodenum. Roger states that simple ligation of the pylorus leads to this physiological death in from seventy-two hours to five days. That, it will be observed, is just without the limit of the twine triangular time control. It is true that Roger did not employ the delayed gastro-enterostomy for a control, and so much that is accidental is certain to enter into all this sort of work that one feels hesitancy either in commenting upon the results obtained by others or impressing one's own experimental findings. It is true, however, that we have observed this fact: Given free drainage of the duodenum through the normal channel, as shown in Fig. 3, the stomach may be obstructed at or near the pylorus more frequently without lethal result until the cutting through of the triangular stoma than if the obstruction were in the duct-bearing portion of the duodenum. Of course, in this type of experiment, with the cutting through of the stoma, there ceases at once to be a reason why the animals should not live for an indefinite period. I do not wish to be understood as saying that no physiological toxic elements arise from the stomach and that the source of the toxicity is strictly duodenal or pancreatic; but we have been struck by the fact that, discounting all consideration of biliary toxemia, which one seems quite justified in doing, at least the chief source of the poison is either in the duodenum or the pancreas. In the light of our present knowledge, and measuring the degree of toxicity by our time drainage unit, rather than attempting to measure it, as Roger has done, in terms of toxic units, we were led to assume that the source of the toxemia was not in the stomach but in the duodenum. This enabled us, for purposes of study, at any rate, to place the oral limit of the lethal line between the pylorus and the papilla of Vater, because until now the question of the influence of the bile has not yet been worked out.

The duct-bearing portion of the duodenum has long been recognized as an area having unknown and profoundly complex physiological properties, and it is in part the object of this paper to demonstrate that the most accurate interpretation and knowledge of the physiological processes going on in this short tube must form the groundwork for future therapeutic progress, be it surgical or medical; not alone on the alimentary canal, but as one should logically expect, as well upon its great glands, the liver and the pancreas. The morphological relationship of the stomach, liver, and pancreas to the duodenum has been graphically portrayed by Mumford, who says that the pancreas, the liver and ducts, and the stomach hang like three apples on a single stem, the duodenum. Whatever affects one often affects the others. What more striking simile could one have? I submit that our studies have carried us still farther and that we are justified in considering not only the morphological relations, but the physiological relations as fixed. Is it not significant, in view of the close morphological relationship of these organs, that we have from unknown causes fatal hemorrhages into the pancreas, fatal dilatation of the stomach, fatal sequels to biliary operations which are not properly drained? I leave the discussion of this to those present more qualified to speak of it than I, and continue with the narration of our experimental observations.

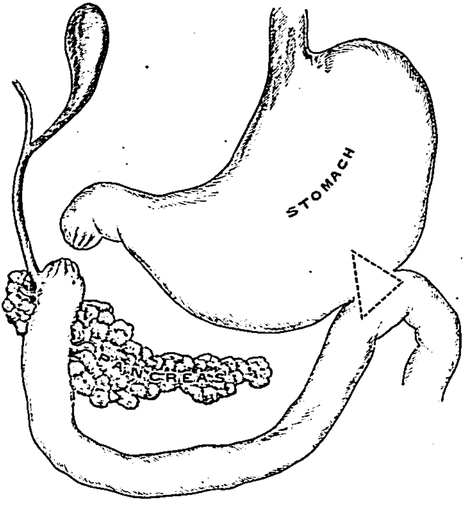

FIG. 3.—Duodenal obstruction; twine triangular control. Both the pancreatic fluid and the bile empty into the aboral loop. In this class of experiments there is usually no fatal outcome during stoma control, even if the stomach contains food at the time of the operation.

Elimination of the Bile by Duct Ligation; Cholecystenterostomy and Transplantation of the Point of Discharge Into the Duodenum. A long series of experiments, painful to the operator in point of technical detail, was created by which the bile was intended to drain into the ileum by the use of the ordinary suture opening between the gall bladder and the gut. For some reason, however, although the technical part was accurately executed, there was in every case a failure of the bile to drain. We finally concluded that there was either a change in its composition, owing to infection from the ileum, or that the secretory function of the liver cells had been abandoned or changed to an absorptive one. In any event, the bile draining or not draining, it was not possible for it to enter the oral loop, as the common duct had been ligated and divided, but the results, so far as the physiological death went, were the same. Death occurred in short-loop dogs before stoma-control

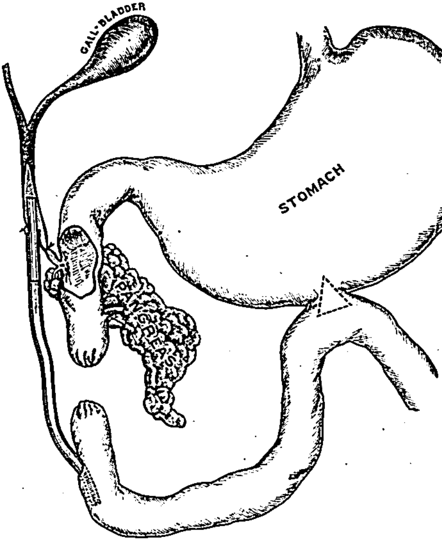

Fig. 4.—Extra-enteric transposition of the biliary secretion (Sullivan's technique). A glass cannula is inserted in the common bile duct; a rubber tube over the glass is stitched to the cut margin of the duct and introduced within the gut aboral to the intestinal obstruction. The bile duct is tied at the entrance to the duodenum.

drainage. To fortify the position and to enable us to feel that we were not superimposing hepatic changes upon those under consideration, Mr. Arthur Sullivan, the senior laboratory assistant, devised means for the direct transplantation of the bile (Figs. 4 and 5). It comprises the reconstruction of the common bile duct, and will form the basis of a communication from him at a later date. The use of this simple and effective technique allowed of sufficient room between the transplanted biliary intake and the greater duct of the pancreas, either for complete section and invagination of the duodenum, or its ligation, as the case might be. Here, again, a sufficient series of experiments demonstrated that the supposed toxicity of the bile, at least in regard to obstructive death, was erroneous. It did not matter whether the bile emptied into the oral (Fig. 6) or aboral loop near the point of obstruction, whether the duct was simply ligated and cut, or whether cholecystileostomy was done, the lethal

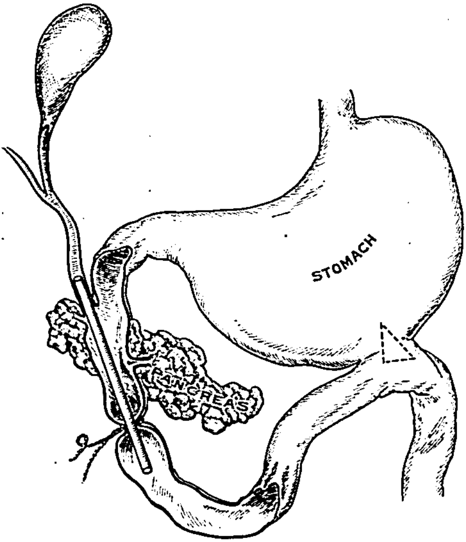

Fig. 5.—Intra-enteric transposition of the biliary secretion; twine stoma control. The forepart of the gut is shaved off to show the tube in position. This technique is difficult of execution and is further objectionable in not permitting actual section of the gut at the point of obstruction. There is apt to be leakage of the intestinal contents around the tube. This vitiates the experiment.

outcome appeared rather conclusively still to be dependent entirely upon the position of the obstruction. In other words, bile, the salts of which are known to possess a very measurable degree of toxicity, was in no way connected with the physiological death under observation.

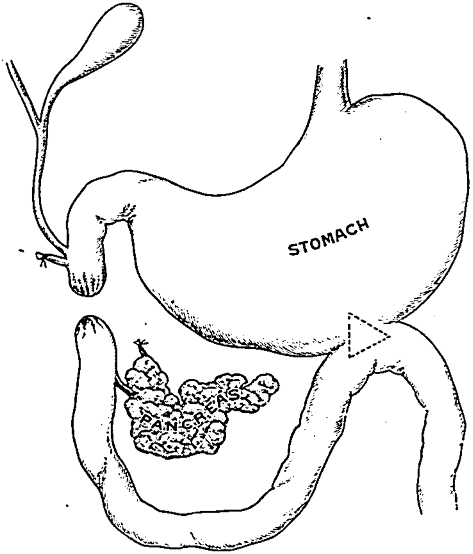

Fig. 6.—Duodenal obstruction between the pancreatic ducts; twine stoma control. The duct of Wirsung is tied and cut so that bile alone enters the oral loop. Drainage of the pancreas by the greater duct is adequate to prevent undue hardening or fat necrosis. The gland continues macroscopically in good condition. Dogs usually live during the period of stoma control

Relation of the Pancreatic Secretion to Intestinal Obstructive Physiological Death. The morphology of the parts does not allow a transposition of the pancreatic secretion, in the first place, because there are two ducts, and in the second place, because they are very short and firmly fixed to the pancreatic tissue (Fig. 7). Any interference with this, no matter however delicate, may lead to fat necrosis and other conditions which confuse the point of issue. By using Sullivan's tubes, however, we were able to move the point of entry of the bile as many centimeters aboral to the papilla of Vater as was convenient. After ligating the lesser duct at its point of entrance beside the papilla and cutting it, we could make certain of having sufficient room to sever and invaginate the duodenum in such manner that all the pancreatic secretion might enter into the oral or the aboral loop. Opie has commented on the fact that drainage of the greater duct would usually suffice to prevent any undue hardening of the pancreatic gland because of retained secretion, and we have been glad to make use of his observation by tying and cutting the lesser duct. The result of these studies was conclusive in one regard: irrespective of the whereabouts of the discharged bile, the dogs lived during stoma control when the pancreatic secretions drained aborally, and they died during stoma control when it was confined in the oral loop. I ask that this be not interpreted too positively, because enough conclusive work has not yet been done to justify too positive conclusions. This may well be pardoned, because of difficulties arising from the excessive sensitiveness of the duct-bearing portion of the duodenum, but we have gone far enough to justify our asking for corroborative evidence from others.

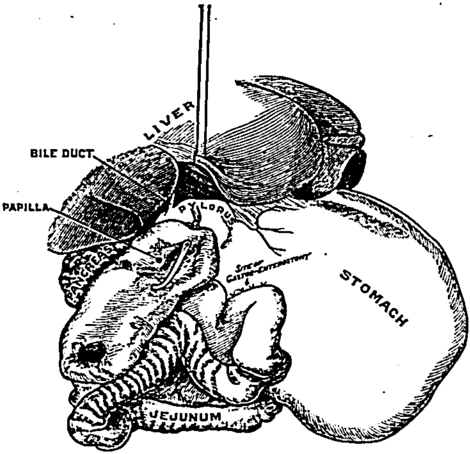

FIG. 7.—Attempted transposition of the pancreatic secretion oral to the duodenal obstruction produced by a ligature. The bile drains aborally. The lesser pancreatic duct is ligated.

We understand that the secretions of the gastric mucosa may be toxic and that this toxicity may be increased many thousands of times by an oral intestinal obstruction, but we have accomplished enough strongly to suggest at any rate that, whatever may be the nature and degree of this toxemia, a toxemia which develops from a disturbance in the duct-bearing portion of the duodenum contains poisons of a much graver nature. It is presumably not to be denied that the increase in amount of gastrotoxins noticed after pyloric obstruction may well be brought about by the interference of a normal duodenal limitation of such toxin development. It is a point of perhaps more than academic interest that Weinland has found an antitryptic ferment to exist in the oral portion of the small intestine. Is one justified in supposing that, as the pancreatic

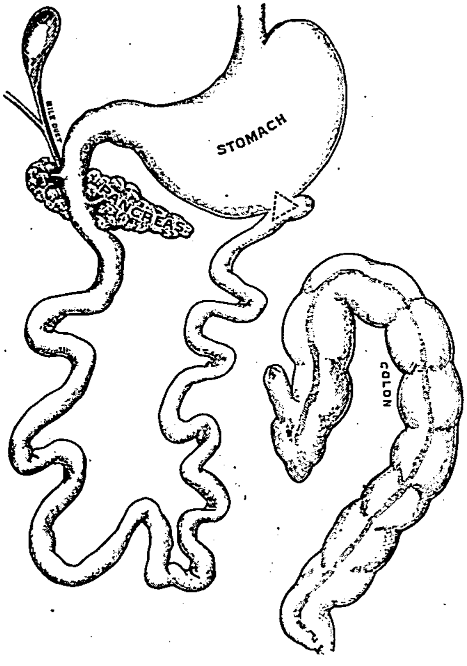

FIG. 8.—The entire small intestine forms the loop. The dogs lived several weeks.

juice, grossly at least, appears to be the lethal agent, the danger from intestinal obstruction grows less and less the farther one places it from the pylorus, and therefore more and more in the antitryptic bearing portions of the canal, and this because of zymotic action. I do not wish to be understood as stating or even suggesting that trypsin alone or as such is responsible for the phenomena; no doubt there are many other ferments and antiferments occurring in the duct-bearing portion of the duodenum, but I speak of the trypsin simply as a representative of the class, because I understand its antibody to have been definitely found. It may indeed be that there is some form of internal secretion produced by the duodenum, possibly not directly associated with the processes of digestion, which is the fundamental factor in causing this physiological form of obstructive death. This should be capable of demonstration by experimental methods. Some such hypothesis is at present necessary in order to explain the singular phenomenon of the protective

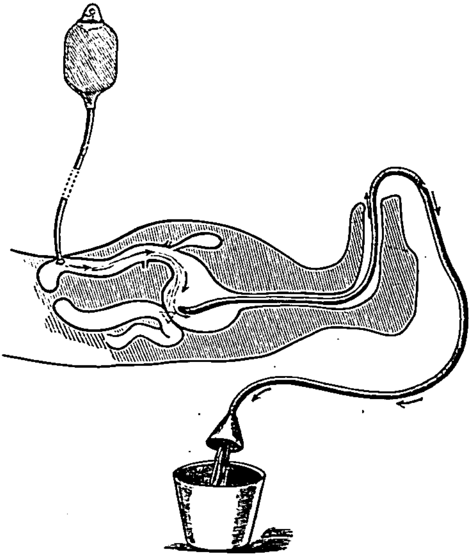

FIG. 9.—Retrograde lavage in a dog. This removes the toxic duodenal products quicker and more thoroughly than ordinary lavage.

power of the first 35 cm. of the intestine, the presence of which in the oral loop sufficing to prevent death before the opening of the triangular control. It may also explain the curious conditions shown in Fig. 8.

THERAPEUTICS. So far the suggestions as to treatment for these dogs have been based upon the belief that we had shown the region of maximum toxicity to be the duodenum rather than the stomach. It seemed, therefore, logical to irrigate the entire region rather than the stomach alone, and this by a sort of retrograde flushing (Fig. 9). This in a dog is easy to accomplish, the pyloric sphincter offering no obstruction either to alkaline or to acid irrigation. It is conceivable that some modification of this method might possibly be employed upon the human being, for constant irrigation of the duct-bearing portion of the duodenum would seem on experimental grounds to be the one logical method of preventing the absorption of the physiological poisons referred to.

A more philosophical method of meeting the conditions might be to transfuse the sick short-loop dog from a long-loop dog, which may be supposed to have manufactured, in the course of his temporary illness occurring before the establishment of gastric drainage, certain antibodies which might be protective to the short-loop dogs. We have done a little work in transfusing the long-loop into the short-loop dog, and have noted improvement in the latter; but this might come from accumulation of the fresh blood rather than from the presence of anti-enzymes. We are, therefore, endeavoring to obtain a serum from the long-loop dog, with which we hope to tide the short-loop dog over his period of hypertoxicity, so that he too may live until the triangular control gives gastric drainage and assures permanent life.